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Enclosure E4 (Formerly referred to as Attachment E4)

### **DESIGN STANDARDS FOR PROTECTIVE LAYER**

1. A minimum of eighteen (18) inches of protective cover classified as SC, SM, SW, GC, GM, GP, and GW, using the Unified Soil Classification system, shall be placed over the liner system (composite liner, drainage layer, and leachate collection system) in a single lift with no compaction.
2. The protective cover material placed on top of the liner system shall meet the following criteria or equivalent criteria:

$$\frac{D_{15} \text{ of Drainage Layer (Sand/Gravel)}}{D_{85} \text{ of Protective Cover}} \leq 5$$

where:  $D_{85}$  - Grain size in millimeters for which 85% of the protective cover material is finer by weight.

$D_{15}$  - Grain size in millimeters for which 15% of the drainage layer is finer by weight.

3. Grain size distribution (ASTM D 422) to the No. 200 (0.075 mm) sieve must be performed for every 1,500 (2,400 ton) cubic yards of drainage layer and protective cover placed on top of the liner system. Hydraulic conductivity (ASTM D 2434) must also be performed for every (4,800 ton) cubic yards for the drainage layer. In the event that coarse/fine aggregate is used in lieu of protective cover, carbonate content testing (ASTM D 3042) must also be performed for every (4,800 ton) cubic yards unless proven otherwise. Using ASTM D 3042, at a pH of 4.0 the carbonate content of the protective material must be no greater than 5% by weight.
4. In the event that a filter fabric (geotextile) is placed on top of the drainage layer, the protective material on top of the filter fabric must meet one of the following criteria:

Criteria #1:

$$\frac{O_{95} \text{ (AOS) of the Filter Fabric (Geotextile)}}{d_{85} \text{ of the Protective Cover (Soil)}} < 2$$

This equation is intended to prevent particles of soil from flowing through the filter fabric (geotextile), and:

$$\frac{O_{95} \text{ (AOS) of the Filter Fabric (Geotextile)}}{d_{15} \text{ of the Protective Cover (Soil)}} > 2$$

This equation is intended to prevent the clogging of the filter fabric (geotextile). AOS refers to the apparent opening size of the fabric.

Criteria #2:

- For soil  $\leq 50\%$  passing the No. 200 sieve,  $O_{95} < 0.59 \text{ mm.}$ ; (i.e. AOS of the fabric  $\geq$  No. 30 sieve).
  - For soil  $> 50\%$  passing the No. 200 sieve;  $O_{95} < 0.30 \text{ mm.}$ ; (i.e. AOS of the fabric  $\geq$  No. 50 sieve).
5. Long-term permittivity of the filter fabric must also be carefully evaluated based on available, appropriate design standards. At a minimum, permeability of the filter fabric ( $K_f$ ) shall be equal to or 10 times greater than the permeability of the soil ( $K_f \geq 10 K_s$ ).
  6. In order to evaluate the influence of retained soil particles on the permittivity of the proposed filter fabric, the Permittee must retain an outside or independent testing agency to perform a gradient ratio test on the representative soil from the proposed landfill site and the proposed filter fabric. A gradient ratio of  $\leq 3$  is recommended. Results of such tests shall be included in as-built report, or as required by permit condition and modification.
  7. An alternative design to the eighteen (18) inches of protective cover may be allowed if, at a minimum, but not limited to, the following criteria are met:
    - Provide a 16 oz/sq. yd. geotextile (ASTM D-5261) on top of the GM;
    - Provide twelve (12) inches of clean gravel (GW, GP \*) classified by the Unified Soil Classification System (USCS) with less than or equal to 5% passing the No. 200 sieve.

- \* GW - Refers to well graded gravel, gravel-sand mixture, little or no fines.
- GP - Refers to poorly graded gravel, gravel-sand mixture, little or no fines.

- Provide hydraulic conductivity of  $1 \times 10^{-3}$  cm/sec or more.

In addition to the above-mentioned specifications, the following information must also be submitted in reference to geotextile specifications:

- Grab elongation (ASTM D 4632);
- Grab tensile strength (ASTM D 4632);
- Puncture resistance (ASTM D 4833);
- Trapezoidal tear strength (ASTM D 4533);
- Ultraviolet (U.V.) (500 Hours) resistance (ASTM D 4355);
- Nature of the fibers, whether it is continuous filament or staple fibers, etc.
- Chemical compatibility of the geotextile;
- pH resistance of the geotextile;
- Polymer composition (i.e., polypropylene, polyester, etc.); structure of geotextile;
- Thermal degradation and oxidation in extreme acidic conditions;
- Creep;
- Abrasion or tumble test;
- Resistance to temperature;
- Resistance to bacteria, (if information is available);
- Resistance to burial deterioration, (if information is available);
- Other information as may be required for a specific product.

8. Other criteria/alternative design to establish the above-mentioned objectives may be allowed if equivalent or better protection is provided to human health and the environment. Following is a list of selected alternative protective covers.

<b>Type of Cover</b>	<b>Application</b>
a. Thirty (30) inches of soil to meet Unified Soil Classification System of SC, SM, GC, GM, GP or GW.	Above geocomposite drain age medium.
b. Eighteen (18) inches of foundry sand.	Above granular layer.
c. Thirty (30) inches of foundry sand.	Above geocomposite drainage medium.
d. Eighteen (18) inches boiler slag.	Above granular layer.
e. Thirty (30) inches of boiler slag.	Above geocomposite drainage medium.
f. Eighteen (18) inches bottom ash.	Above granular layer.
g. Thirty (30) inches of bottom ash .	Above geocomposite drain-layer

This document may be modified periodically to reflect changes in methodology. If you

have any questions regarding this guidance, please contact the Solid Waste Engineering staff of this office for assistance.

## **References**

1. Koerner, R.M. "Designing with Geosynthetics", Prentice Hall, Englewood Cliffs, New Jersey, 1986, p. 62.
2. Holtz, R.D., Kovacs, W.D., "An Introduction to Geotechnical Engineering", Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1981.